August 31, 2010

Final Report

FUEL OIL TANK EMISSIONS TESTING FEASIBILITY STUDY

Prepared by

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Battelle
The Business *of* Innovation

For

Eastern Research Group, Inc.
Austin, TX

August 31, 2010

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FUEL OIL TANK EMISSIONS TESTING FEASIBILITY STUDY

by
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Battelle

Acknowledgments

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- Mr. Paul Gibbs of GOST Company, for coordinating this field testing with the oil field lease operator, providing his technology, and providing field support.

- Ms. Carmen Pedraza of the TCEQ for securing a FLIR Systems, Inc. (FLIR) GasFindIR Midwave (MW) infrared (IR) camera for use during field testing .

- Ms. Alice Cone of TCEQ for operating the FLIR GasFindIR MW IR camera throughout the course of field testing.

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List of Abbreviations

CH_4	Methane
cm^3	Cubic centimeter
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	n-Butane
C_5H_{12}	n-Pentane
DOT	Department of Transportation
DQI	Data quality indicator
ERG	Eastern Research Group, Inc.
FLIR	FLIR Systems, Inc.
ft	Foot
ft agl	Foot above ground level
GPA	Gas Processors Association
GC	Gas chromatography
HASP	Health and safety plan
$i\text{-}C_4H_{10}$	Isobutane
$i\text{-}C_5H_{12}$	Isopentane
IR	Infrared
mm	Millimeter
mph	Miles per hour
mscf	Thousand standard cubic feet
MW	Midwave
N_2	Nitrogen
oz/in^2	Ounce per square inch
O_2	Oxygen
PPE	Personal protective equipment
ppmv	Parts per million by volume
Psi	Pound per square inch
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
TCEQ	Texas Commission on Environmental Quality
U.S.	United States
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
°F	Degree Fahrenheit

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Executive Summary

This final report details the results of field testing, conducted on August 23 and 24, 2010 to evaluate the vapor sampling capabilities of the GOST apparatus in a 500 barrel unheated atmospheric oil storage tank at an oil and gas lease operation in Midland County, Texas. Note the title of the Work Order from Texas Commission on Enviornment Quality (TCEQ) which funded this work, referenced a “heated” fuel oil tank; however the tank where the GOST apparatus was tested was unheated. The fact that an unheated fuel oil tank was what was available for use was noted in the Quality Assurance Project Plan that was approved by TCEQ with the notice to proceed.

Field testing consisted of performing compositional analysis of gas samples collected at times when the GOST apparatus was operational and when it was not operationing; making observations of releases of organic compounds from the unheated atmospheric oil storage tank at times when the GOST apparatus was operational and non-operational; and conducting measurements of the volume of gas recovered by the GOST apparatus using a gas volume totalizer installed at the field site. The field testing and final report were completed under TCEQ Work Order No. 582-7-84003-FY10-28.

The GOST apparatus is a vapor recovery device that operates as a float, and in the case of the field tested system, inside an unheated atmospheric oil storage tank. When suspended on top of the oil layer in the unheated atmospheric oil storage tank, the vapor opening of the GOST apparatus is maintained above the oil layer liquid surface, therby allowing the collection of vapors from inside the tank.

During the first day, and for part of the second day, of field testing, the GOST apparatus was placed in an operational state and the gas volume totalizer at the field site was reset to zero. The field test team collected three gas samples for compositional analysis from the vapor recovery line prior to the tie-in with the lease’s main gas export line at various points through the day. A FLIR Systems, Inc. (FLIR) GasFindIR Midwave (MW) camera was operated to image organic compound releases from the unheated atmospheric oil storage tank.

On the second day of field testing, the volume of gas collected by the GOST apparatus during the previous 24 hour-period was recorded, and simultaneous gas samples were collected from the vapor recovery line and from a valved overhead line exiting from the top of the unheated atmospheric oil storage tank that had the GOST apparatus installed. Next, the GOST apparatus was placed in a non-operable state and the field test team collected three additional gas samples for compositional analysis from the valved overhead previously described. As was completed on the previous day of field testing, a FLIR GasFindIR MW camera was operated to image organic compound releases from the unheated atmospheric oil storage tank.

A total of eight gas samples were collected throughout the course of field testing and analyzed for gas composition by Gas Processors Association (GPA) Method 2261-00 – Analysis for Natural Gas and Similar Gaseous Mixtures by Gas Chromatography. Three gas samples were collected from a sampling port located between the gas volume totalizer and the tie-in with the lease's main gas export line when the GOST device was in operation. Second, a set of samples were collected simultaneously from this sampling point and from a sampling point located in a valved overhead line exiting from the unheated atmospheric oil storage tank in which the GOST apparatus was installed. Lastly,three gas samples were collected from that same sampling point located in a valved overhead line when the GOST apparatus was not in operation. Table 1 summarizes the results of the composition of the gas collected during this field test when the GOST apparatus was operational and non-operational.

Table 1. Composition of Gas Samples Collected when GOST Apparatus is Operational and Non-Operational

GOST Apparatus Operational Status	Operating			Not-Operating		
Number of Samples	3(a)			3		
	Min.	Ave.(b)	Max.	Min.	Ave.(b)	Max.
Nitrogen	5.2577	11.7524	22.2485	0.2033	7.2354	11.5532
Oxygen	0.0813	1.7331	5.0044	0.0018	0.4827	1.2179
Methane	51.2815	63.2586	70.5842	45.8368	60.2186	67.8276
Carbon dioxide	0.9962	1.2046	1.3416	0.929	1.2177	1.465
Ethane	7.9526	9.2885	10.0224	9.22	10.3255	12.2369
Propane	5.4001	5.8142	6.0409	4.9439	7.6026	12.5014
i-Butane	0.7331	0.7521	0.7656	0.5573	1.4118	3.0553
n-Butane	2.3456	2.3665	2.3847	1.647	3.8713	8.0957
i-Pentane	0.7436	0.7700	0.796	0.4777	1.3580	3.0346
n-Pentane	0.835	0.8766	0.9211	0.5318	1.8767	4.4731
Hexanes	0.7978	0.8567	0.9207	0.5423	1.8017	4.2509
Heptanes	1.1996	1.3272	1.4053	1.0583	2.5981	5.3812
Heating Value, Dry (Btu/scf)	1,080.4	1,226.9	1,305.3	1,156.6	1,507.7	2,149.7

(a) Excludes the gas samples collected simulateously from the vapor recovery line and overhead sampling point.
(b) Arithmetic average.

On the second day of field testing, the field test team observed the pressure relief valve serving the tank battery at the field test site opening and releasing organic compound emissions to the atmosphere approximately 6 minutes after the GOST apparatus was deactivated. Organic compound emissions continued to be observed by the field test team with the FLIR GasFind IR MW camera, emanating from the pressure relief valve, in addition to the releases from the 1/8 inch tank safety gauge on the unheated atmospheric oil storage tank that did not have the GOST apparatus installed. At the end of second day of field testing, the field test team was able to observe organic compound emissions from the pressure relief valve cease approximately 1 minute after the GOST apparatus was reactivated. At this point, organic compound emissions were observable only from the 1/8 inch tank safety gauge. The observations made using the FLIR GasFindIR MW camera showing the pressure relief valve release after the GOST apparatus was deactivated and the observations showing the pressure relief valve reseat itself after the GOST apparatus was reactivated demonstrate that when the GOST apparatus is activated, the headspace pressure at the tank battery is not high enough to activate the pressure relief valve. Thus, these observations demonstrate that headspace gas was being removed from the tank battery when the GOST device is operated. This conclusion is supported by the gas volume totalizer reading of 33.732 thousand standard cubic feet (mscf) of gas collected during a 24-hour period between 10:47 AM on 8/23/2010 and 10:47 AM on 8/24/2010 when the GOST apparatus was in operation; this physical measurement supports the conclusion drawn from the observations made with the FLIR GasFindIR camera that the GOST apparatus, when in operation, collected gas from inside the unheated atmospheric oil storage tank

Chapter 1
Introduction

This document is the final report detailing the performance of the tasks and activities specified in TCEQ Work Order No. 582-7-84003-FY10-28 with Eastern Research Group under which Battelle is a subcontractor This final report contains six chapters and includes/addresses the following components as specified under "Task 5 – Final Report" in the Work Order.

- An executive summary or abstract,
- A brief introduction that discusses background and objectives, including relationships to other studies;
- A discussion of pertinent accomplishments, shortfalls, and limitations of the work completed under each Work Plan task.
- Recommendations for what should be considered next as a new study.

This final report provides a comprehensive overview of activities undertaken and data collected and analyzed during the work. In addition, this final report includes an evaluation of the feasibility of installing the GOST in oil storage tanks, based on factors including cost, ease of installation, and maintenance requirements.

1.1 Background

During a 2005 Texas Air Quality II study, a helicopter-mounted HAWK passive infrared (IR) camera recorded large plumes at heated oil storage tanks in the Houston area that suggest volatile organic compound (VOC) emissions may be under-reported from these sources. Currently, there is no United States Environmental Protection Agency (USEPA)-approved method to measure emissions from these types of storage tanks. TCEQ had interest in understanding the performance of a new tool called the "GOST" that is designed for capturing storage tank vapors.

1.2 Technology Description

The GOST apparatus is a vapor recovery device that operates as a float, in the case of the field tested system, inside an unheated atmospheric oil storage tank. When suspended on top of the oil layer in the storage tank, the vapor opening of the GOST apparatus is maintained above the oil layer liquid surface, thereby allowing the collection of vapors from inside the tank. The number of floats required to support the GOST apparatus on the liquid surface depends on the weight of the braided stainless steel tubing used to convey gases from the gas apparatus out of the tank and to the gas recovery system; the greater the weight (i.e., the longer the length) of the braided stainless steel tubing, the more floats are required. Figure 1 depicts a four float GOST apparatus.

Figure 1. A four-float GOST apparatus.

At the oil and gas lease site where field testing occurred under this Work Order, an eight-float GOST apparatus is installed in one of two unheated atmospheric crude oil storage tanks (see Section 3.3). Inside this tank, the GOST apparatus is connected by braided stainless steel tubing to an internally plastic-coated tank hatch with prewelded flanges. The eight-float GOST apparatus is approximately 88 inches in horizontal diameter and each of the eight floats are made from 14 gauge 316 stainless steel. Each of the eight 316 stainless steel float posts are mounted onto the 4 inch diameter 316 stainless steel cell. The top of the cell is 6 inches in diameter at the vapor opening. The cell is approximately 19 inches in length from the top of the vapor opening to the point at which the GOST apparatus connects to the braided stainless steel tubing. There are no moving parts on the GOST apparatus. The flanges on the exterior of the tank hatch connect to hard pipe, which runs to a scrubber pot, compressor, and gas volume totalizer. From the gas totalizer, the pipe connects to the lease's main gas export line. Figure 2 illustrates the GOST apparatus and gas recovery system as installed in the unheated atmospheric storage tank at the field site.

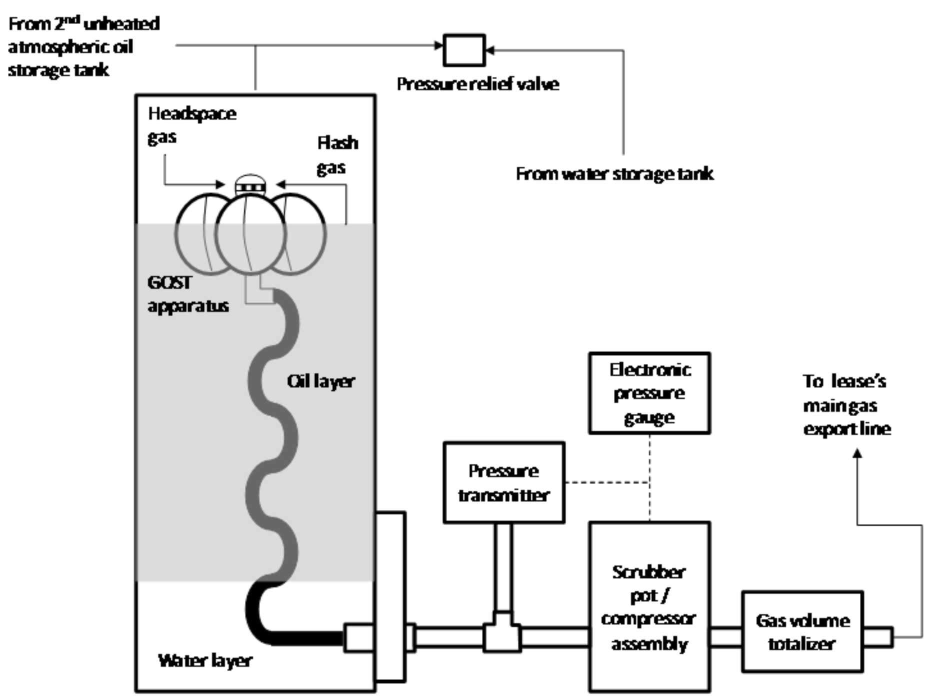

Figure 2. GOST apparatus and gas recovery system installed at lease site.

At the field site, product exits the production wells and is piped into a two-stage separator. At the two stage separator gas is flashed from the product and exported into the lease's main gas export line for sale. The pressure in the two stage separator was 52 pounds per square inch (psi) at the end of the first test day and 55 psi at the end of the second test day (temperature is unknown because the separator did not have a temperature gauge). The remaining liquid product (containing water, oil, and entrained gas) is piped to an unfired hydrotreater three-phase separator. At the unfired hydrotreater three-phase separator, separated water is piped to a 500 barrel water storage tank, flashed gas is exported to the lease's main gas export line, and remaining product (containing oil and entrained gas) is transported to one of two 500 barrel unheated atmospheric oil storage tanks. The pressure and temperature in the three-phase separator were 28 psi and 98 degrees Fahrenheit (°F) at the end of the first test day and 28 psi and 90 °F at the end of the second field test day. During both days of field testing, production oil was piped into the unheated atmospheric oil storage tank in which the GOST apparatus was installed. During the first day of field testing, the entire lease produced 24 barrels of oil and 510 mscf of gas (including the volume of gas collected by the GOST apparatus). During the second day of field testing, the entire lease produced 18 barrels of oil and 522 mscf of gas.

At the tank battery, consisting of both 500 barrel unheated atmospheric oil storage tanks and the 500 barrel water storage tank, the headspaces of each of the two unheated atmospheric oil storage tanks and the water storage tank are tied together with equalization lines. The headspace pressure in the unheated atmospheric oil storage tank in which the GOST apparatus is installed is controlled by a pressure relief valve which opens at a pressure of 5 ounces per square inch (oz/in^2). This pressure relief valve is also tied into the second unheated atmospheric oil storage tank and the water storage tank. A pressure transmitter electronically conveys the headspace pressure measured at the GOST apparatus inlet to an electronic pressure gauge and to the control system for the compressor. The compresser is actuated when a pressure measurement of 1.8 oz/in^2 is detected and is deactivated when a pressure measurement of 0.25 oz/in^2 is detected by the transmitter. When actuated, the compressor conveys either flash gas, headspace gas, or a mixture of both from inside the unheated atmospheric storage tank in which the GOST apparatus is installed to the lease's main gas export line for sale.

1.3 Purpose and Objectives

The purpose of this project was to demonstrate and document the capabilities of the GOST apparatus in an industrial facility. The project investigated whether the GOST apparatus could feasibly collect headspace samples in a storage tank, through the following Work Order and Work Plan tasks:

- ***Task 1: Work Plan*** – Develop, submit, and obtain approval of a Work Plan, a Quality Assurance Project Plan (QAPP), and a Health and Safety Plan (HASP) describing the work to be performed for TCEQ.
- ***Task 2: Secure Subcontractor Services*** – Retain the services of a subcontractor capable of assessing the GOST apparatus' capabilities for vapor headspace sampling.
- ***Task 3: Secure Field Test Site*** – Secure a site that has a GOST apparatus already installed in a storage tank to participate in the field testing of the GOST apparatus.
- ***Task 4: Conduct Field Testing of the GOST Apparatus*** – Coordinate and complete all activities necessary to field test the vapor sampling capabilities of the GOST apparatus.
- ***Task 5:Final Report*** – Develop and deliver a final report to the TCEQ Project Manager (this document).

Chapter 2
Technical Approach; Securing Subcontractor Services and Field Test Site

2.1 Work Plan

Task 1 of TCEQ Work Order No. 582-7-84003-FY10-28 required the development of a Preliminary Work Plan and its subsequent submittal to TCEQ for approval. Along with additional information required for the Work Plan (see following paragraph), the Preliminary Work Plan included a plan detailing the time and cost for preparing the project QAPP. The Preliminary Work Plan was submitted to the TCEQ Project Manager on 07/06/2010. The TCEQ Project Manager approved the Preliminary Work Plan on 07/12/2010.

Task 1 of TCEQ Work Order No. 582-7-84003-FY10-28 also required the development of a Work Plan and its subsequent submittal to TCEQ for approval. This Work Plan identified ERG's project manager, key personnel, quality assurance (QA)/quality control (QC) procedures (i.e., QAPP), project timeline, budget, technical approach/method, any models or software to be used by ERG, any miscellaneous information or elements (i.e., HASP) required by the Work Order, and ERG's signature. The Work Plan was submitted to the TCEQ Project Manager on 07/28/2010. The TCEQ Project Manager approved the Work Plan on 07/30/2010. The project QAPP and HASP were submitted to the TCEQ Project Manager under separate cover; further details of the project QAPP and HASP are provided in the following subsections.

No shortfalls or limitations of the work completed under this Work Order and Work Plan task were identified.

2.1.1 Quality Assurance Project Plan

A draft QAPP was developed as part of the Work Plan and submitted under separate cover to the TCEQ Project Manager on 07/28/2010. A final QAPP was developed and submitted under separate cover to the TCEQ Project Manager on 07/29/2010. The TCEQ Project Manager approved the QAPP on 07/30/2010. The QAPP included discussion of the following items:

- ***Project Description and Objectives*** – Project/environmental systems evaluated, and project purpose and objectives.
- ***Project Organization and Responsibilities*** – Project staffing/responsibilities and project milestone/schedule.
- ***Scientific Approach of the Project*** – Experimental design, general approach, and process measurements.
- ***Sampling Procedures*** – Site considerations, procedure descriptions, sample quantities, sample preservation, sample numbering, and sample transfer.

- ***Measurement Procedures*** – Analytical methods and calibration procedures.
- ***Quality Metrics*** – QC checks and additional QA objectives.
- ***Data Analysis, Interpretation, and Management*** – Data reporting requirements, data validation procedures, data analysis procedures, and data storage requirements.
- ***Reporting*** - List of planned deliverables and due dates.

2.1.2 Health and Safety Plan

A HASP was developed as part of the Work Plan and submitted under separate cover to the TCEQ Project Manager on 07/30/2010. No comments were received from TCEQ addressing the contents of the HASP. The HASP identified the following items:

- ***Project Identification***
- ***Emergency Information***
- ***Site Access Requirements***
- ***Potential Job Hazards***
- ***Required Personal Protective Equipment (PPE)***
- ***Project-Specific Safety Requirements.***

2.2 Securing Subcontractor Services

Task 2 of TCEQ Work Order No. 582-7-84003-FY10-28 required that ERG retain the services of a subcontractor capable of providing the necessary personnel and equipment needed to conduct all activities detailed in the Work Order. ERG retained Battelle Memorial Institute (Battelle) as a subcontractor, under subcontract number TCEQ 84003/6. In this role, Battelle assisted in the development of the Work Plan and QAPP, developed the HASP, conducted field testing to assess the ability of the GOST apparatus to collect headspace vapor samples in an unheated atmospheric oil field tank, and developed this final report.

No shortfalls or limitations of the work completed under this Work Order and Work Plan task were identified.

2.3 Securing a Field Test Site

Task 3 of TCEQ Work Order No. 582-7-84003-FY10-28 required ERG and Battelle to secure a field site that already had a GOST apparatus installed in a storage tank for use in testing of the GOST apparatus. To accomplish this task, ERG and Battelle worked with Mr. Paul Gibbs of the GOST Company.

Mr. Paul Gibbs informed ERG and Battelle that the GOST apparatus is installed and operational at only a single site, an oil and gas lease operation in Midland County, Texas. At this location, the GOST apparatus is installed in one unheated atmospheric crude oil storage tanks at the tank battery, as described in Section 2.2.

Mr. Gibbs successfully coordinated with the lease operator to secure access to the lease by the field test team. Confirmation that the field testing could be conducted by the field test team was provided via email from Mr. Paul Gibbs to ERG and Battelle, and subsequently provided to the TCEQ Project Manager via email on 8/03/2010.

A single limitation of the work completed under this Work Order and Work Plan task has been identified. Because the GOST apparatus is installed only in one location and only in an unheated atmospheric oil storage tank at this location, field testing of the GOST apparatus yielded results specific only to this application. The reader is cautioned against extrapolating the results of this field test and feasibility analysis to other storage tank applications (i.e., heated oil tanks, floating roof tanks, etc.).

Chapter 3
Field Testing of the GOST Apparatus

Task 4 of TCEQ Work Order No. 582-7-84003-FY10-28 required ERG and Battelle to coordinate and complete all activities necessary to field test the vapor sampling capabilities of the GOST apparatus in an industrial setting. The following subsections detail field test design and the field test procedures used.

3.1 Test Overview

This field test evaluated the vapor recovery capabilities of the GOST apparatus in an unheated atmospheric oil storage tank at an oil and gas lease site in Midland County, Texas. During field testing, gas samples were collected for compositional analysis at times when the GOST apparatus was operating as well as times when it was not operating. Additionally, the field test team utilized a FLIR GasFindIR MW camera to image organic compound emissions released from the thief hatches, pressure relief valve, and the safety tank gauges of the unheated atmospheric oil storage tanks both at times when the GOST apparatus was operating and when it was not operating. Finally, totalizer readings were collected of the volume of gas recovered by the GOST apparatus while the field test team was onsite and the GOST apparatus was operating.

A site visit was conducted by Battelle field test personnel on August 4, 2010. The purpose of this site visit was to scout the oil and gas lease operation for field test sampling locations, to observe a GOST apparatus which has not been installed in a tank system, and interview GOST Company personnel regarding the cost of the GOST apparatus, as well as its maintenance needs and ease of use. Additionally, prior to field testing, a small set of previously collected gas volume totalizer readings and a single gas compositional analysis result were provided by the GOST Company.

Field testing of the GOST apparatus was conducted August 23 and August 24, 2010 at the field site in Midland County, Texas. The field test was conducted with support from the GOST Company, Caprock Laboratories Inc., and TCEQ.

3.2 Experimental Design

3.2.1 Gas Recovery Volume

At the beginning of the portion of field testing during which the GOST apparatus was operated, the gas recovery volume totalizer was reset to zero. The totalizer measured the volume of gas recovered by the GOST apparatus and transferred to the lease's main gas export line. The totalizer was not reset during the course of the test day. 24 hours later, field test personnel recorded the total volume of gas recovered by the GOST apparatus. The gas recovery volume totalizer was a Fox Thermal Instruments,Inc. model FT2 gas mass flow meter and temperature transmitter.

3.2.2 Compositional Analyses of Gas

During this field test, gas samples were collected at times when the GOST apparatus was in operation and when it was not in operation. All gas samples were collected into 300 cubic centimeter (cm^3) Department of Transportation (DOT)-certified stainless-steel double ended cylinders provided by the analytical laboratory (Caprock Laboratories, Inc.). Collected gas samples were transported to Caprock Laboratories, Inc. at the completion of each field test day. Caprock Laboratories, Inc. analyzed each collected gas sample for nitrogen (N_2), oxygen (O_2), methane (CH_4), ethane (C_2H_6), propane (C_3H_8), isobutane (i-C_4H_{10}), n-butane (C_4H_{10}), isopentane (i-C_5H_{12}), n-pentane (C_5H_{12}), hexanes, and heptanes using GPA Method 2261-00 – Analysis for Natural Gas and Similar Gaseous Mixtures by Gas Chromatography.

Figure 3. Photograph of sampling point in the vapor recovery line.

When the GOST apparatus was in operation, gas samples were collected from a sampling port located between the gas volume totalizer and the tie-in with the lease's main gas export line. Figure 3 shows this sampling point. In addition, a pair of samples were collected simultaneously from this sampling point and from a sampling point located in a valved overhead line exiting from the unheated atmospheric oil storage tank in which the GOST apparatus was installed.

When the GOST apparatus was not in operation, gas samples were collected from that same sampling point located in a valved overhead line exiting from the unheated atmospheric oil storage tank in which the GOST apparatus was installed. Figure 4 shows this sampling location.

3.2.3 Organic Compund Imaging Using a FLIR GasFindIR MW Camera

Figure 4. Photograph of sampling point in valved overhead line exiting the storage tank in which the GOST apparatus is installed.

During this field test, a FLIR GasFindIR MW camera, supplied by TCEQ, was operated to image organic compound releases from the unheated atmospheric oil storage tank during times when the GOST apparatus was operating as well as during times when the GOST apparatus was not operating. During the field test, the FLIR GasFindIR MW camera was operated by Ms. Alice Cone (TCEQ). Ms. Cone attempted to image organic compound emissions released from the thief hatches, pressure relief valve, and the safety tank gauges of the unheated atmospheric oil storage tanks. Each observation was conducted using the eye piece of the FLIR GasFindIR MW camera and with the camera's standard 25 millimeter (mm) lens. The operational settings of the FLIR GasFindIR MW camera were altered throughout the course of testing to provide for the best imaging of organic compound emissions. On the first day of field testing, the operational setting of the FLIR GasFind IR MW camera was ME off, Auto, HIST, WH until 11:10 AM at which time the settings were changed to ME off, Auto, HIST, BL. At 11:16 AM camera settings were changed to ME off, Manual, HIST, BL, where they remainded for the rest of the day. On the second day of field testing, the operational setting of the FLIR GasFind IR MW camera was ME off, Auto, HIST, BL. Qualitative descriptions of each observation event (i.e., description of relative plume intensity, sun location relative to the observer, general meteorological conditions, viewing background) were recorded into the field notebook. In addition, videos were recorded using the FLIR GasFindIR MW camera for some of the observations made during both days of field testing. After field testing, meteorological conditions for the two days of field testing were obtained from the National Weather Service station at the Midland International Airport, located approximately 17 miles to the north-northeast of the field test site.

On the first day of field testing the field test team set up the FLIR GasFindIR MW camera in a location approximately 72 feet (ft) from the tank battery. This location was chosen because all storage tanks at the tank battery could be viewed such that the wind would carry any organic compound emissions in a direction perpendicular to the camera's field of view (i.e., camera observations were made facing west while the wind at the field site was noted as blowing out of the south-southwest). The viewing background from this location was the sky behind the tank battery. Figure 5 displays the view from the vantage point for camera observation on the first day of field testing. In Figure 5, the unheated atmospheric oil storage tank on the right is the tank in which the GOST apparatus is installed (referred to as Tank 2 in this report) and the tank on the left is the unheated atmospheric oil storage tank that does not have the GOST apparatus installed (referred to as Tank 1 in this report).

Figure 5. Photograph displaying the view from the FLIR GasFindIR MW camera vantage point on the first day of field testing.

On the second day of field testing the field test team set up the FLIR GasFindIR MW camera in a location approximately 50 ft from the tank battery. This location was chosen to orient the wind direction (and therefore, any organic compound emission plumes) in a position perpendicular to the camera's field of view (i.e., camera observations were made facing northwest while the wind at the field site was noted as blowing out of the northeast). The viewing background from this location was the sky behind the tank battery. Figure 6 displays the view from the vantage point for camera observation of the second day of field testing. As shown in Figure 6, the unheated atmospheric oil storage tank in which the GOST apparatus is installed (i.e., Tank 2, the center tank in the figure) is not directly viewable, however, the pressure relief valve and the unheated atmospheric oil storage tank which does not have the GOST apparatus installed (Tank 1, the left tank in the figure) are viewable.

As of the writing of this report, videos that were recorded using the FLIR GasFindIR MW camera have yet to be processed into still images. Thus, images of organic compound releases observed using the FLIR GasFindIR MW camera are not included in this report, but presumably can be obtained from Ms. Cone of TCEQ at a later date.

3.2.4 Field Testing Procedures

Field testing of the GOST apparatus was conducted on August 23 and 24, 2010. The field testing was conducted following the scientific approach and procedures detailed in the final TCEQ-approved QAPP except as noted.

Figure 6. Photograph displaying the view from the FLIR GasFindIR MW camera vantage point on the second day of field testing.

Upon arriving at the field site on the first day testing, the field test team, which included Mr. Brian M. Boczek, PE (Battelle Work Order Leader), Mr. Paul Gibbs (GOST Company), and Ms. Alice Cone (TCEQ), found the GOST apparatus in operation. At 10:47 AM, the field test team reset the gas recovery volume totalizer to zero. The field test team then collected three gas samples for compositional analysis from the sampling port located between the the gas volume totalizer and the tie-in point with the lease's main gas export line at various intervals through the day. Details regarding the collection of each gas sample were recorded in the field notebook. The field test team only collected gas samples during times when the GOST apparatus was actively exporting gas from the storage tank; the field test team knew that this was occurring when the compressor was activated (i.e., was exporting gas from the unheated atmospheric storage tank to the lease's main gas export line) and the electronic pressure gauge read between 1.8 and 0.25 oz/in^2 of pressure.

At various intervals throughout the day (but not necessarily occurring at the same time as the physical collection of gas samples for compositional analysis), Ms. Cone utilized a FLIR GasFindIR MW camera to image organic compound emissions from the thief hatches, pressure relief valve, and the safety tank gauges of the unheated atmospheric storage tanks. A total of 13 observations were made of the thief hatch, the pressure relief valve, and the safety tank gauge. Qualitative descriptions of each observation event (i.e., description of relative plume intensity, sun location relative to the observer, general meterological conditions, viewing background) were recorded into the field notebook. In addition, videos were recorded using the FLIR GasFindIR MW camera for some of the observations.

At the conclusion of the first day of field testing, the GOST apparatus was allowed to continue its operation until the second day of operation so that the volume of gas collected by the GOST apparatus could be recorded from the gas volume totalizer.

On the second day of field testing, the field test team arrived at the field site to find the GOST apparatus in operation. The field test team then collected gas samples simultaneously from the two sampling points described in Section 4.2.2. At 10:47 AM, the field test team then recorded the volume of gas collected by the GOST apparatus. After the volume was recorded, the GOST apparatus was placed in a non-operational state at 11:02 AM and the headspace pressure inside the unheated atmospheric oil storage tanks was allowed to increase. The field test team then collected three gas samples for compositional analysis from the sampling port located on the valved overhead pipe exiting from the top of the unheated atmospheric oil storage tank in which the GOST apparatus is installed, at various intervals through the day. Details regarding the collection of each gas sample were recorded in the field notebook. The field test team verified that the gas compressor was not operating (i.e., was not exporting gas from the unheated atmospheric storage tank to the lease's main gas export line) before all gas samples were collected.

Throughout the course of the second field test day, Ms. Cone utilized a FLIR GasFindIR MW camera to image organic compound emissions from the thief hatch, pressure relief valve, and the safety tank gauge of the unheated atmospheric storage tank. A total of 15 observations were made of the thief hatches and the safety tank gauges on the unheated atmospheric oil storage which did not have the GOST apparatus installed. The field of view from the FLIR GasFindIR MW camera vantage point on this field test day also allowed the pressure relief valve serving all of the tanks in the tank battery to be viewed in each observation. Qualitative descriptions of each observation event (i.e., description of relative plume intensity, sun location relative to the observer, general meterological conditions, viewing background) were recorded into the field notebook. In addition, videos were recorded using the FLIR GasFindIR MW camera of some of the observations. All gas samples collected on the second day of field testing and a field blank cylinder that was maintained by the field test team thoughout both days of field testing, were transported to Caprock Laboratories, Inc. for compositional analysis. After the conclusion of this day of field testing and before leaving the field site, the GOST apparatus was placed back into operation.

During field testing, several deviations from the QAPP occurred. As described in Section 3.3 "General Approach" of the QAPP, it was anticipated that the GOST apparatus would not be operational during day one of field testing. However, day one of field testing was completed with the GOST apparatus in operation and day two of field testing was conducted without the GOST apparatus in operation. This change was made to ensure that the pressure relief valve on the unheated atmospheric oil storage tank would not be releasing on the first day of field testing. This change reduced the potential risk that the pressure relief valve would not reseat after releasing and render the GOST apparatus non-functional thereafter because the headspace pressure in the unheated atmospheric oil storage tank would no longer increase and actuate the gas compressor (see additional discussion of pressure relief valve issues relating to GOST apparatus operation in Section 6.4). No adverse affect on data quality is expected as a result of this change.

The QAPP also stated that the gas samples would be collected into one liter sample canisters, however Caprock Laboratories, Inc. provided 300 cm^3 sample canisters. The 300 cm^3 sample size was still large enough for Caprock Laboratories, Inc. to conduct the compositional analyses; thus, no effect on data quality is expected.

Third, the simultaneous collection of gas samples from the two different sampling points was not identified in the QAPP. Because Caprock Laboratories, Inc. provided additional sample canisters beyond the seven canisters originally requested as a field testing precaution, additional canisters were available for sampling. The field test team collected these simultaneous samples in an effort to identify if the composition of the gas collected by the GOST apparatus differed from the composition of the headspace gas as a whole. Though this set of samples was not identified for collection in the QAPP, their collection was conducted using the procedures identified in the QAPP. Thus, an enhancement on data quality is expected since additional samples for compositional analysis were collected and analyzed as a result of this deviation.

Finally, the QAPP identified that the absolute pressure of the sampling cylinders would be measured and recorded prior to and after gas sample collection. This was not completed. All gas samples collected in this field test were collected from pressurized lines, and thus, the collected gas samples were also pressurized. Caprock Laboratories, Inc. verified that all collected gas samples were still pressurized upon their delivery to their analytical laboratory. Because all gas samples maintained a positive pressure until analysis, there is no possibility of ambient air leaking into the cylinders and diluting the concentrations of analytes in the samples. Thus, no effect on data quality is expected.

3.3 Operational Factors

Operational factors such as the maintenance needs, ease of use, and installation requirements of the GOST apparatus were discussed with Mr. Paul Gibbs of the GOST Company during the initial site visit prior to field testing. Operational factors are discussed in Section 7.1 (Feasibility Analysis).

Chapter 4
Quality Assurance/Quality Control

The "Quality Assurance/Quality Control (QA/QC) Procedures" section of TCEQ Work Order No. 582-7-84003-FY10-28 identified this field test as QA Category Level III which required an audit of data quality for 10 percent of all data and a report of QA findings to be included in the final report. The following sections detail the QA/QC procedures and results for this field test.

QA/ QC procedures were performed in accordance with the QAPP developed for this field test. As noted in Chapter 3, there were four deviations from the QAPP, none of which are expected to adversely affect data quality, and the work was performed as described in the previous sections. In addition, a single limitation of the work completed under this Work Order and Work Plan is identified in Section 3.3.QA/QC procedures and results are described in the following subchapters.

4.1 Analytical Method Quality Control

The quality of the analytical measurements made during field testing was assured by adherence to the requirements of the data quality indicators (DQIs) for the analytical method critical measurements, including requirements to assess the bias and accuracy of the gas chromatography (GC) laboratory analysis by developing calibration curves traceable to certified gas standards, and performing positive and negative control checks. The following sections present key data quality results from these methods.

4.1.1 Bias of Gas Chromatography Analytical Method

A DQI was established for this field test for the bias of the GC analytical method used to quantify the composition of gas samples collected during the field test. This DQI was assessed through initial calibration, and by analyzing positive and negative control samples. These assessments are discussed in the following paragraphs.

Initial Calibration. Initial calibration of the GC was conducted in accordance with GPA Method 2261-00; pure component gas standards (greater than 99.999 percent) and zero standards were used individually to confirm detector linearity and develop instrument-specific response factors for each component when the GC was installed at the analytical laboratory in January 2010. Prior to analyzing any samples that were collected in this field test, detector linearity was confirmed by running a certified calibration gas standard of known composition (less than the pure standards and in a composition near to that of natural gas) and analyzing the results using the instrument-specific response factors (i.e., conducting a linearity check). The responses for all components were less than 1.0 percent different than the concentration of the component in the certified calibration gas standard. Thus, the minimum acceptance criteria of a 2.0 percent difference during initial calibration was met.

Positive Control Checks. Positive control checks were required to be performed at a minimum frequency of 10 percent of all samples tested using one concentration of calibration gas standard. The minimum acceptance criteria for positive control checks was that the positive control check response were less or equal to a 10 percent error in response from the certified gas calcibration standard. Eight collected gas samples and a single field blank sample were analyzed by the GC analytical laboratory and three positive contol checks were performed for each of the compounds analyzed for by the laboratory exceeding the minimum frequency of 10 percent of samples tested. The results of the positive control checks are provided in Table 2. As demonstrated by Table 2, all positive control checks completed had a percent error < 0.87 percent, and thus met the minimum accepatance criterion.

Table 2. Summary of Positive Control Check Responses

		QAQC Cal Gas #1		QAQC Cal Gas #2		QAQC Cal Gas #2	
Compound Measured by GC Method	**Expected Response (Mole %)**	**Actual Response (Mole %)**	**Percent Error[(a)]**	**Actual Response (Mole %)**	**Percent Error[(a)]**	**Actual Response (Mole %)**	**Percent Error[(a)]**
Nitrogen	2.0434	2.0431	-0.01%	2.0428	-0.03%	2.0427	-0.03%
Oxygen	0.0000	0.0000	N/A[(b)]	0.0000	N/A[(b)]	0.0000	N/A[(b)]
Methane	62.4313	62.4312	0.00%	62.4308	0.00%	62.4286	0.00%
Carbon dioxide	0.9546	0.9533	-0.14%	0.9526	-0.21%	0.9537	-0.09%
Ethane	15.6681	15.6646	-0.02%	15.6639	-0.03%	15.6669	-0.01%
Propane	11.3161	11.3173	0.01%	11.3175	0.01%	11.3186	0.02%
i-Butane	1.1825	1.1815	-0.08%	1.1824	-0.01%	1.1820	-0.04%
n-Butane	3.7371	3.7370	0.00%	3.7373	0.01%	3.7372	0.00%
i-Pentane	0.7846	0.7848	0.03%	0.7845	-0.01%	0.7843	-0.04%
n-Pentane	0.8038	0.8042	0.05%	0.8048	0.12%	0.8040	0.02%
Hexanes	0.4721	0.4762	0.87%	0.4751	0.64%	0.4739	0.38%
Heptanes	0.6064	0.6068	0.07%	0.6083	0.31%	0.6081	0.28%

(a) Percent error is calculated as [(Actual Response, mole percent – Expected Response, mole percent)/ Expected Response, mole percent] x 100%.
(b) N/A – not applicable. Calibration gas did not contain oxygen. Thus, a percent error cannot be calculated.

Negative Control Checks. Negative control checks were required to be performed at a minimum frequency of one out of every 10 samples tested. The minimum acceptance criterion for this assessment is that the response of all negative control checks must be lower than the response of the linearity check standard for the chemical analyzed. Eight collected gas samples and a single field blank sample were analyzed by the GC analytical laboratory and three negative contol checks were performed for each of the compounds analyzed for by the laboratory exceeding the minimum frequency of 10 percent of samples tested. All compounds analyzed in the three negative control checks were reported by the GC analytical laboratory as being below the minimum acceptance criteria.

4.2 Audits

A single type of audit was performed during the field test, a data quality audit. Audit procedures for the data quality audit are described further below.

4.2.1 Data Quality Audit

Records generated in the field test received a one-over-one review before these records were used to calculate, evaluate, or report results. 100% of the field test data was reviewed for quality by the Battelle Work Order Leader, and at least 10% of the data acquired during the field test were independently audited by a Battelle Quality Assurance Officer. The data were traced from the initial acquisition, through reduction to final reporting to ensure the integrity of the reported results.

Chapter 5
Test Results

Task 4 of TCEQ Work Order No. 582-7-84003-FY10-28 required ERG and Battelle to provide QA-checked field data to TCEQ. The following sections provide the QA-checked results of the field testing of the GOST apparatus conducted August 23 and 24, 2010.

5.1 Gas Recovery Volumes

As descriped in Sections 3.1 and 3.2.1, the field test team monitored the gas recovery volume totalizer during the first day of field testing to determine the volume of gas recovered by the GOST apparatus while the field test team was onsite and the GOST apparatus was operating. Additionally, prior to field testing, a small set of gas volume totalizer readings was provided by the GOST Company. Table 3 presents the volume of gas in units of mscf recovered by the GOST apparatus from both of these sources.

5.2 Compositional Analysis of Collected Gas Samples

As descriped in Sections 3.1 and 3.2.2, the field test team collected gas samples for compositional analysis during both the first day of field testing when the GOST apparatus was in operation and during the second day of field testing when then GOST apparatus was not operating. Table 4 presents the results of all compositional analyses completed by Caprock Laboratories, Inc. for all gas samples collected as part of this field test. GC analysis of the field blank sample returned concentrations of 76.6269, 18.9409, 2.6572 mole percent for nitrogen, oxygen, and methane, respectively, and less than 0.5000 mole percent ,individually, for all other compounds, analyzed.

Table 3. GOST Apparatus Gas Recovery Volumes

Date	Total Elapsed Time (hr)[(a)]	Gas Volume Collected (mscf)	Average Volumetric Gas Collection Rate (mscf/hr) [(a, b)]	Data Source
05/13/2009		21		GOST Co.
05/14/2009		48		GOST Co.
05/15/2009		23		GOST Co.
6/14/2009		52		GOST Co.
6/15/2009		64		GOST Co.
6/20/2009		56		GOST Co.
6/21/2009		58		GOST Co.
6/22/2009		57		GOST Co.
6/23/2009		51		GOST Co.
6/24/2009		53		GOST Co.
6/25/2009		64		GOST Co.
6/26/2009		63		GOST Co.
6/27/2009		63		GOST Co.
6/28/2009		69		GOST Co.
6/29/2009		71		GOST Co.
6/30/2009		84		GOST Co.
8/23/2010 – 08/24/2010	24	33.732	1.406	This test

(a) Totalizer measurements supplied by the GOST Company did not include the times at which the gas recovery volume totalizer was read. Therefore, the elapsed time during which the gas was collected could not be determined and an average volumetric gas collection rate could not be determined.

(b) Average volumetric gas collection rate, mscf/hr = Gas volume collected, mscf / elapsed time, hr.

5.3 Organic Compound Imaging Using a FLIR GasFindIR MW Camera

As described in Sections 4.1 and 4.2.3, the field test team utilized a FLIR GasFind IR MW camera in an attempt to image organic compound releases from the unheated atmospheric oil storage tanks during times when the GOST apparatus was operating as well as times when the GOST device was not operating. Table 5 presents the results of the observations completed both when the GOST apparatus was operational and when it was not operational.

When the GOST apparatus was operational, the field test team observed organic compound emissions from the 1/8 inch tank safety gauges of the unheated atmospheric oil storage tank in which the GOST device was installed using the FLIR GasFindIR MW camera. These organic compound emissions continued throughout the day when observed with the FLIR GasFindIR MW camera.

On the second day of field testing, the field test team observed the tanks' pressure relief valve first actuate and release organic compound emissions to the atmosphere approximately 6 minutes after the GOST apparatus was deactivated. Organic comound emissions, eminating from the pressure relief valve, in addition to the releases from the 1/8 inch tank safety gauge on the unheated atmospheric oil storage tank that did not have the GOST apparatus installed, continued to be observed by the field test team with the FLIR GasFindIR MW camera. At the end of the second day of field testing, the field test team was able to observe organic compound emissions

Table 4. Compositional Analysis Results

GostApparatus Operational Status	Operating[a]						Not Operating[c]		
Gas Sample ID	10201SIG1[b]	08-22	09-01	09-22	13-04[c]	13-09	14-01	14-24	15-21
Date and Time	01/14/2009	8/23/2010 11:35	8/23/2010 14:06	8/23/2010 15:46	8/24/2010 10:57	8/24/2010 10:57	8/24/2010 11:37	8/24/2010 14:03	8/24/2010 15:48
Gas Composition (mole percent)									
Nitrogen	2.8514	22.2485	7.7510	5.2577	73.6814	9.6848	9.9496	0.2033	11.5532
Oxygen	0.0000	5.0044	0.0813	0.1135	17.6821	1.7710	0.2283	0.0018	1.2179
Methane	53.0468	51.2815	67.9100	70.5842	6.5169	65.0101	67.8276	45.8368	66.9914
Carbon dioxide	1.0441	0.9962	1.2761	1.3416	0.1669	1.1922	1.4650	0.9290	1.2592
Ethane	14.4664	7.9526	9.8904	10.0224	0.8089	9.3983	9.5195	12.2369	9.2200
Propane	14.2155	5.4001	6.0409	6.0015	0.4498	5.7841	5.3624	12.5014	4.9439
i-Butane	1.9556	0.7331	0.7656	0.7575	0.0537	0.7448	0.6228	3.0553	0.5573
n-Butane	6.1592	2.3692	2.3847	2.3456	0.1611	2.3286	1.8711	8.0957	1.6470
i-Pentane	1.6249	0.7960	0.7694	0.7436	0.0532	0.7540	0.5618	3.0346	0.4777
n-Pentane	1.7145	0.9211	0.8736	0.8350	0.0613	0.8625	0.6252	4.4731	0.5318
Hexanes	1.3544	0.9207	0.8517	0.7978	0.0636	0.8837	0.6119	4.2509	0.5423
Heptanes	1.5672	1.3766	1.4053	1.1996	0.2981	1.5859	1.3548	5.3812	1.0583
Heating Value, Dry (Btu/scf)	1,692.9	1,080.4	1,295.0	1,305.3	122.1	1,258.5	1,216.9	2,149.7	1,156.6

(a) All gas samples, with the exception of 13-09, were collected from sampling point located after the gas totalizer in the gas recovery line.
(b) Gas sample collected by the GOST Company, Inc. and compositional analysis completed by Caprock Laboratories, Inc.
(c) All gas samples collected from an overhead line exiting the unheated atmospheric oil storage tank in which the GOST apparatus was installed.

from the pressure relief valve cease approximately 1 minute after the GOST apparatus was reactivated. At this point, organic compound emissions were observable only from the 1/8 inch tank safety gauge. The observations made by the field test using the FLIR GasFindIR MW camera on both field test days indicate that when the GOST apparatus is operating a portion of the headspace gas from the unheated atmospheric oil storage tanks was collected rather than released into the atmosphere; when the GOST device is non-operational, the headspace gases are released from the pressure relief valve into the atmosphere

As of the writing of this report, videos that were recorded using the FLIR GasFindIR MW camera have yet to be processed into still images. Thus, images of organic compound releases observed using the FLIR GasFindIR MW camera are not included in this report, but presumably can be obtained from Ms. Cone of TCEQ at a later date.

Table 6 presents the reported meterological data during field testing.

Table 5. Results of Observations Conducted with FLIR GasFindIR MW Camera

Date	Time	GOST Device in Operation?	Qualitative Description	Video Recorded? (Video ID)
8/23/2010	10:50	Yes	Conducted survey of entire site using IR camera to observe emissions from any source.	Yes (Video 500)
8/23/2010	11:10	Yes	Observed emission from 1/8 inch safety tank gauge on Tank 2 (i.e., the unheated atmospheric oil storage tank in which the GOST apparatus is installed). Observed emission seems to increase when compressor is on. No other emissions are noted from thief hatch or pressure relief valve Viewing background is the clear sky and winds are out of the south-southwest. Sun is to the back of the observer at approximately 10 o'clock in the horizon. GOST Compressor is off.	Yes (Video 501)
8/23/2010	11:15	Yes	Observed emission from 1/8 inch safety tank gauge on Tank 2 which seemed to increase in volume from previous observation. No other emissions are noted from thief hatch or pressure relief valve Viewing background is the clear sky and winds are out of the south-southwest. GOST compressor is on.	No
8/23/2010	11:23	Yes	Observed emission from 1/8 inch safety tank gauge on Tank 2 only. Unknown if GOST compressor was activated or not.	Yes (Video 502)
8/23/2010	11:41	Yes	Observed emission from 1/8 inch safety tank gauge on Tank 2 only. Unknown if GOST compressor was activated or not.	Yes (Video 503)
8/23/2010	11:54	Yes	Same as previous description	No
8/23/2010	12:05	Yes	Observed emission from 1/8 inch safey tank gauge on Tank 2. Emission is described as intermittent puffing. Emission appears to be becoming more voluminous. Unknown if GOST compressor was activated or not.	No
8/23/2010	12:20	Yes	Same as previous description.	No

Table 5. Results of Observations Conducted with FLIR GasFindIR MW Camera (continued)

Date	Time	GOST Device in Operation?	Qualitative Description	Video Recorded? (Video ID)
8/23/2010	14:15	Yes	Observed starting with GOST compressor non-operational and viewed until the compressor activated. An emission is still seen from the 1/8 inch tank safety gauge on Tank 2 but seems less than before. Wind speed has increased and is now slightly gusty. The increase in wind speed could by why the observed emissions seem less. Sun is directly overhead of the camera observer.	Yes (Video 504)
8/23/2010	14:40	Yes	Emissions observed from 1/8 tank safety gauge on Tank 2 and appears the same as previous observation.	No
8/23/2010	14:58	Yes	Emissions observed from 1/8 tank safety gauge on Tank 2 and appears the same as previous observation.	No
8/23/2010	15:21	Yes	Emissions observed from 1/8 tank safety gauge on Tank 2 and appears the same as previous observation. Wind has calmed a bit and is not as gusty. Sun is located above the observer in approximately a 1:00 position between the observer and the tank battery.	No
8/23/2010	15:48	Yes	Conducted a final survey of the entire tank battery. No emissions observed other than from the 1/8 inch tank safety gauge which appears as previous. Conducted observation during the entire recovery cycle of the GOST apparatus (i.e., compressor on until the compressor deactivated). No difference described in the release when the compressor was activated and when it was deactivated (see earlier description of compressor cycling at 11:10).	Yes (Video 505)
8/24/2010	10:32	Yes	Conducted Initial Survey. Observed emissions from 1/8 inch tank safety valve on Tank 1 (i.e., the unheated atmospheric oil storage tank without the GOST apparatus installed). The observed emission is described as tailing over really bad to the southwest from 1/8 inch tank safety valve on Tank 1.	Yes (Video 506)

Table 5. Results of Observations Conducted with FLIR GasFindIR MW Camera (continued)

Date	Time	GOST Device in Operation?	Qualitative Description	Video Recorded? (Video ID)
8/24/2010	11:02	No	GOST device was deactivated at 11:00 for the rest of the test day. Observed emissions from 1/8 inch tank safety valve on Tank 1 and there was not much change in the observed emission. At 11:04, the observed emissions seemed to pick up more from the 1/8 inch tank safett gauge. At 11:06, the pressure relief valve was observed to release and begin to emit to the atmosphere, in addition, to continuing to release from the 1/8 inch tank safety gauge. The release from the pressure relief valve is audible as a hissing sound. Release from pressure relief valve is a continuous plume. By 11:24, the thief hatches have not popped open.	Yes (Video 507)
8/24/2010	11:33	No	Observed emission from both the pressure relief valve and from the 1/8 inch tank safety valve on Tank 1. Emission described as the same as the previous observation.	
8/24/2010	11:50	No	Wind seems to be dispersing emissions, but the amount is the same. Quantity stabilized approximately 8 to 10 minutes after the GOST apparatus was turned off.	Yes (Video 508)
8/24/2010	12:04	No	Same as previous description.	No
8/24/2010	12:20	No	Same as previous description.	No
8/24/2010	12:33	No	Same as previous description.	No
8/24/2010	12:44	No	Same as previous description.	Yes (Video 509)
8/24/2010	14:10	No	Observed emission from both the pressure relief valve and from the 1/8 inch tank safety valve on Tank 1. Emission described as the same although it is apparent from observation of the plume from the pressure relief valve that wind speed has increased. Wind speed is felt as increasing and gusty. Winds are still noted as coming out of the northeast. The sky has now turned overcast.	Yes (Video 510)

Table 5. Results of Observations Conducted with FLIR GasFindIR MW Camera (continued)

Date	Time	GOST Device in Operation?	Qualitative Description	Video Recorded? (Video ID)
8/24/2010	14:54	No	Beginning to sprinkle slightly at the field site, wind speed and ambient temperature have dropped down some. Observed emission from both the pressure relief valve and from the 1/8 inch tank safety valve on Tank 1. The "opacity" of the plume from the pressure relief valve appears to be increasing. This is possibly due to the rain clouds in the viewing background causing a greater thermal difference between the background and the vapor plume causing the plume to look more concentrated	Yes (Video 511)
8/24/2010	15:09	No	Observed emission from both the pressure relief valve and from the 1/8 inch tank safety valve on Tank 1. The "opacity" of the plume from the pressure relief valve appears to be decreasing during observation; almost looks like it did around 12:00 hour.	No
8/24/2010	15:21	No	Observed emission from both the pressure relief valve and from the 1/8 inch tank safety valve on Tank 1. The "opacity" of the plume from the pressure relief valve appears to be decreasing during observation relative to the previous observation; almost looks like it did around 12:00 hour.	No
8/24/2010	15:38	No	Same as previous description	No
8/24/2010	15.43	No	No description recorded	Yes (Video 512)
8/24/2010	15:52	No/Yes	Began observation at 15:52 at which time the field test team activated the GOST device. At 15:53:25, the pressure relief valve appeared to reseat itself as no more releases were observed from the valve. Emissions continue to be observed from the 1/8 inch tank safety valve on Tank 1.	Yes (Video 513)

Table 6. Meteorological Conditions at Midland International Airport During Field Testing

Date	Time (central daylight)	Wind Direction and Speed (mph)[a]	Visibility (miles)	Weather	Sky Condition	Temperature (°F) Air	Temperature (°F) Dew Point
8/23/2010	10:44	S 9	10	Fair	Clear	91	53
8/23/2010	11:04	S 8	10	Fair	Clear	93	52
8/23/2010	11:24	S 10	10	Fair	Clear	94	52
8/23/2010	11:44	SE 12 G 17	10	Fair	Clear	95	53
8/23/2010	12:04	SE 12	10	Fair	Clear	96	51
8/23/2010	12:24	S 14 G 21	10	Fair	Clear	97	50
8/23/2010	12:44	S 8 G 14	10	Fair	Clear	97	48
8/23/2010	13:04	S 10 G 18	10	Fair	Clear	98	47
8/23/2010	13:24	SE 9 G 16	10	Fair	Clear	98	48
8/23/2010	13:44	SW 10	10	Fair	Clear	99	47
8/23/2010	14:04	S 8	10	Fair	Clear	99	46
8/23/2010	14:24	S 9 G 16	10	Fair	Clear	101	44
8/23/2010	14:44	S 9	10	Fair	Clear	101	44
8/23/2010	15:04	SW 8 G 17	10	Fair	Clear	101	43
8/23/2010	15:24	S 6	10	Fair	Clear	101	42
8/23/2010	15:44	SW 5	10	Fair	Clear	102	41
8/23/2010	16:04	SW 7	10	Fair	Clear	102	41
8/24/2010	10:44	NE 17	10	Partly Cloudy	Scattered Clouds at 10,000 feet above ground level (ft agl)	87	65
8/24/2010	11:04	N 17 G 25	10	Fair	Clear	88	65
8/24/2010	11:24	NE 18 G 25	10	Fair	Clear	88	65
8/24/2010	11:44	NE 20 G 25	10	Fair	Clear	89	65
8/24/2010	12:04	NE 16 G 28	10	Fair	Clear	91	64
8/24/2010	12:24	NE 14 G 26	10	Fair	Clear	92	64
8/24/2010	12:44	NE 18 G 28	10	Fair	Clear	92	63
8/24/2010	13:04	NE 21 G 26	10	Fair and Breezy	Clear	93	63
8/24/2010	13:24	N 21 G 25	10	Fair and Breezy	Clear	93	62
8/24/2010	13:44	NE 18 G 31	10	Fair	Clear	93	62
8/24/2010	14:04	NE 21 G 25	10	Partly Cloudy and Breezy	Scattered clouds at 6,000 and 11,000 ft agl	94	62
8/24/2010	14:24	N 16 G 29	10	Partly Cloudy	Scattered clouds at 6,000 and 12,000 ft agl	92	63
8/24/2010	14:44	N 20 G 26	10	Mostly Cloudy	Scattered clouds at 6,000 and 7,000 ft agl and broken clouds at 12,000 ft agl	93	62
8/24/2010	15:04	NE 21 G 29	10	Mostly Cloudy and Breezy	Scattered clouds at 5,500 ft agl and broken clouds at 7,000 and 11,000 ft agl	92	62

Table 6. Meteorological Conditions at Midland International Airport During Field Testing (continued)

Date	Time (central daylight)	Wind Direction and Speed (mph)[(a)]	Visibility (miles)	Weather	Sky Condition	Temperature (ºF)	
						Air	Dew Point
8/24/2010	15:24	NE 21 G 28	10	Mostly Cloudy and Breezy	Scattered clouds at 5,500 and 7,000 ft agl and broken clouds at 11,000 ft agl	92	61
8/24/2010	15:44	NE 22 G 29	10	Mostly Cloudy and Breezy	Scattered clouds at 5,500 and 7,000 ft agl and broken clouds at 10,000 ft agl	91	62
8/24/2010	16:04	NE 22 G 29	10	Partly Cloudy and Breezy	Scattered clouds at 5,500 and 12,000 ft agl	91	63
8/24/2010	16:24	NE 25 G 30	10	Partly Cloudy and Breezy	Scattered clouds at 5,500 and 6,500 ft agl	92	64
8/24/2010	16:44	NE 23 G 29	10	Mostly Cloudy and Breezy	Scattered clouds at 5,500 ft agl and broken clouds at 11,000 ft agl	92	63
8/24/2010	17:04	NE 20 G 25	10	Mostly Cloudy	Scattered clouds at 5,000 ft agl and broken clouds at 11,000 ft agl	91	63
8/24/2010	17:24	N 17 G 29	10	Partly Cloudy	Scattered clouds at 5,000 ft agl	89	64
8/24/2010	17:44	NE 23 G 32	10	Partly Cloudy and Breezy	Scattered clouds at 4,900 and 6,000 ft agl	89	64
8/24/2010	18:04	N 22 G 28	10	Partly Cloudy and Breezy	Scattered clouds at 4,900 and 6,000 ft agl	89	64

(a) Wind notation is a follows: Wind out of Direction_Wind speed (mph). Gusting winds are notated as G_Wind speed (mph). NE indicates northeast, N indicates north, NW indicates northwest, SE indicates southeast, S indicates south, SW indicates southwest. For example, N 22 G 28 indicates winds out of the north at 22 mph gusting to 28 mph.

Chapter 6
Feasibility Analysis and Recommendations for Future Study

Task 5 of TCEQ Work Order No. 582-7-84003-FY10-28 required ERG and Battelle to evaluate the feasibility of installing the GOST in oil storage tanks. The evaluation considered factors including cost, ease of installation, and maintenance requirements.

6.1 Feasibility Analysis

On the second day of field testing, the field test team observed the pressure relief valve first activate and then release organic compound emissions to the atmosphere approximately 6 minutes after the GOST apparatus was deactivated. Organic compound emissions continued to be observed by the field test team with the FLIR GasFind IR MW camera, emanating from the pressure relief valve, in addition to the releases from the 1/8 inch tank safety gauge on the unheated atmospheric oil storage tank that did not have the GOST apparatus installed. At the end of second day of field testing, the field test team was able to observe organic compound emissions from the pressure relief valve cease approximately 1 minute after the GOST apparatus was reactivated. At this point, organic compound emissions were observable only from the 1/8 inch tank safety gauge. The observations made using the FLIR GasFindIR MW camera showing the pressure relief valve release after the GOST apparatus was deactivated and the observations showing the pressure relief valve reseat itself after the GOST apparatus was reactivated demonstrate that when the GOST apparatus is activated the headspace pressure in tanks at the tank battery is not increased to a pressure high enough to activate the pressure relief valve. Thus, these observations demonstrate that headspace gas is being removed from the tank battery when the GOST device is operated. This conclusion is supported by the gas volume totalizer reading of 33.732 mscf of gas collected between 10:47 AM on 8/23/2010 and 10:47 AM on 8/24/2010 when the GOST apparatus was in operation.

GOST Company personnel provided the following information regarding ease of installation, maintenance requirements, and cost to the Battelle Work Order Leader during the initial site visit conducted on August 4, 2010 and during the course of the field test. The eight float GOST device installed at the field site was field-assembled by the GOST company in approximately 6 hours. The unheated atmospheric oil storage tank was empty, and the existing tank hatch removed for access into the tank. Two of the float posts and floats were installed onto the GOST cell outside on the unheated atmospheric storage tank (the posts and floats were those that were parallel to each other). The GOST apparatus was then inserted into the empty unheated atmospheric oil storage tank. Once inside, the remaining posts and floats were added to the GOST apparatus. Next, the stainless steel braided tube was attached to the GOST apparatus and to the interior connections of a new internally plastic-coated tank hatch, provided by the GOST company. The flanges in the internally plastic coated tank hatch were prewelded prior to delivery to the field site. The internally plastic-coated tank hatch was then sealed onto the unheated atmospheric oil storage tank.

The remaining installation steps were completed by a three man team in approximately three days. Hard piping was installed from the prewelded flanges to the scrubber pot/compressor assembly. The scrubber pot/compressor are skid assembled and were also delivered to the field site. A pressure transmitter and electronic pressure gauge were also installed. From the scrubber pot/compressor skid, hard piping was installed leading to a new gas volume totalizer. Finally, the hard pipe was tied into the lease's existing main gas export line.

The GOST apparatus has no moving parts, and thus, regular maintenance on the GOST device itself is not required. The useful life of the GOST apparatus is not known; GOST company personnel indicate that, because the GOST apparatus is constructed entirely of 316 stainless steel, they would expect the GOST apparatus to last between 30 to 40 years in a "sweet" environment and between 20 to 30 years in a "sulfury" environment. The GOST apparatus, however, relies on several other pieces of equipment – an operable pressure relief valve, a compressor, and a pressure transmitter and controls – to operate. Maintenance of these ancillary pieces of equipment should be conducted in accordance with the manufacturer's recommended maintenance frequency and procedures. In addition, the useful life of each of these separate pieces of ancillary equipment may vary.

As an anecdote to the discussion of the requirement for regular maintenance of equipment ancillary to the GOST apparatus, it is important to note that this field test was originally scheduled to be completed between August 2 and August 5, 2010. The field testing could not be completed on those dates, however, because on the afternoon of July 29, 2010, the gas compressor was found in to be unable to actuate (i.e., the headspace pressure in the unheated atmospheric oil storage tank was not rising above 1.8 oz/in^2). Upon inspection, the pressure relief valve was found to be reseating improperly,thereby allowing the headspace vapor to release from the unheated atmospheric oil storage tank rather than being collected by the GOST device and exported from the lease. This event underscores the importance of performing regular inspection and maintenance of all ancillary equipment.

According to GOST Company personnel, the cost of the GOST apparatus installed at this field site was $12,000. According to GOST Company personnel, the cost of the GOST apparatus will vary dependent upon the market price of 316 stainless steel. Additionally, the cost of all valves and piping was an additional $5,500 at the field test site included additional piping for liquid skimming and fire extinguishing though these functions were not evaluated in this field test. It is likely that the installation cost of valves and piping would decrease if the GOST apparatus is installed only with vapor recovery capabilities. The cost of labor to install the valve and piping at the field test site was $4,100. The cost of an optional control flow meter is $4,500 and the monthly lease cost for the scrubber pot/compressor skid is $750 per month.

The economic feasibility of installing a GOST device in unheated atmospheric oil storage tanks is unknown but will likely depend on site-specific factors, including but not limited to the total volume of gas produced at a lease site, the availability of a gas processing plant in the vicinity of the lease, and the sale price of natural gas. Future studies could be conducted to evaluate the economic feasibility of installing the GOST apparatus in unheated atmospheric oil storage tanks at oil and gas lease sites throughout the State of Texas.

6.2 Recommendations for Future Study

As discussed in Section 3.3, because the GOST apparatus is installed only in one location and only in an unheated atmospheric oil storage tank at this location, field testing of the GOST apparatus yielded results specific only to this application. Further study should be considered for other tank applications, such as heated oil tanks, if the GOST apparatus is to be applied to differing situations beyond unheated atmospheric oil storage tanks.

In addition, as discussed in Section 7.1, the economic feasibility of installing the GOST apparatus in unheated atmospheric oil stage tanks is unknown. A detailed economic feasibility study could be conducted to evaluate the costs and benefits of installing the GOST apparatus in unheated atmospheric oil storage tanks at various oil and gas lease operations throughout the State of Texas.